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A PHILOSOPHICAL ENQUIRY

Into the PROPERTIES of ELECTRICITY.

In which is contain'd a
Confutation of the Solutions which have been hitherto given of it, and the moſt probable Reaſon of the late ſurprizing Experiments.

In a LETTER to a FRIEND.

Neſcius equidem non ſum, eandem judicii libertatem aliis relinquendam quam ipſe uſurpaverim. Verulamius, L. ii. De Augmentis Scientiarum.

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A PHILOSOPHICAL

ENQUIRY, &c.

Dear SIR,

IN Compliance with your kind Requeſt, I ſit down to give you ſome Account of the Electrical *Phænomena*, which at preſent make ſo great a Noiſe both in the learned World, and among the inquiſitive Part of the common People: And as you have importuned me ſo much from time to time to have my Thoughts concerning the Cauſe of theſe uncommon Experiments, I ſhall propoſe to you my Notions with ſome ſhare of that Diffidence, which becomes Philoſophical Enquiries of all Sorts, and hope by this means to engage you, Sir, in your turn to ſet all my Errors to rights in this Matter.

You know, my Friend, that the word Electricity was firſt applied to that Property which Amber was found to have when violently rubbed, of attracting light Bodies of all Kinds. 'Tis uncertain how ſoon this Property was diſcover'd to belong to other Bodies treated in the ſame manner; however it was afterwards found in Glaſs, Wax, Reſins, ſolid Bitumens, and in general in moſt unctuous ſolid Bodies, as well as in Diamonds, *&c.*

I do not remember any Account of the Time when theſe Diſcoveries were enlarged; but it was found afterwards, that, as ſoon as any light Matter had acquired an electrical Virtue, it was no longer attracted by the Agent, which the Moment before had attracted it, but on the contrary was repelled with a very great Force; and this repulſive Power continued till the fugitive Matter had touch'd any adjacent Body, to which it inſtantly communicated it's own electric Power; and then, if within the Sphere of Attraction of any other Electric, it was forcibly drawn to that, as it had been at firſt, and was again driven away inſtantaneouſly. Thus for inſtance, they found a Feather eaſily attracted by a Glaſs Tube electrified; but as ſoon as it had once touched the Tube, it fled off, and would ſhun the ſame in all Directions, till the Feather had loſt it's Electricity by touching ſome other Body, and then it was immediately in an attractive State to the Tube.

Upon farther Inquiries, it was diſcover'd that the attractive Power as well as the Repulſive could be imparted to other Bodies beſides the Tube. For it was found that a Boy ſuſpended in ſilken or woollen Chords in the Air, and being electrified at his Head, his Feet attracted and then repelled Leaf-gold, Feathers, or other light Matters; beſides it was found to act almoſt equally ſtrong at ten Foot, and at ten Inches from the Tube, provided the Power was convey'd by a fit Conductor, of which kind are all dried Animal Subſtances.

In the next Place they obſerved, when any Body was very much impregnated with the electrical Power, upon the Contact of any Non-electric Subſtance, the Electric often ſnapped, crackled, and ſometimes emitted Rays of Light copiouſly. This is better illuſtrated by ſuſpending a long Pole in ſilken Chords, and hanging a ſmall Bundle of Threads at one End; then having excited the electrifying Power in a Glaſs Tube of about an Inch Diameter, by graſping a Piece of brown Paper round it and rubbing it violently up and down, apply the electric Tube to the Threads, and inſtantly the other End of the Pole ſnaps, crackles, and emits rays of Light copiouſly. The ſame Effects are produced by turning a Glaſs Globe round it's own Axis, as is afterwards taken notice of.

Or if a Perſon ſtands on Wax, Reſin, or any other originally electric Subſtance, and holds in one Hand a Cane, on which a Bundle of Threads is ſuſpended, and at that time being electrify'd as before touch another Perſon, they mutually hear a Snap, and feel a ſharp pricking Pain, which frequently laſts a conſiderable Time afterward.

Or if heated Spirits of Wine, Oil of Turpentine, *Frobenius*'s Phlogiſton, (which is a ſort of dulcified Spirit of Vitriol) Filings of Steel in a State of Diſſolution with Oil of Vitriol, Camphire, &c. I ſay, if any of theſe be firſt heated, ſo as to emit Fumes conſiderably, and then brought within the Sphere of Activity of the electrified Perſon, and he touch the Spirits of Wine, or put his Hand into the denſeſt Fumes, then the Snap is heard, and the Flame inſtantaneouſly communicated to the heated inflammable Matter, which burns now as ſtrong as if it had been kindled at the Culinary Fire.

Or if the electrified Perſon ſtanding on Wax Cakes, inſtead of touching the inflammable Bodies, *viz.* the heated Spirit of Wine, *&c.* ſhall hold in one Hand the Veſſel with the heated Spirits in it, and a ſecond Perſon bring his Finger very near the Surface of the Spirits, they will then be fired by the electric Rays that firſt ſtruck upon the ſecond Perſon, and were afterwards reflected from the Body on which they had before impinged.

If a Perſon ſtanding on Wax Cakes be electrified by Means of the Threads, and at the ſame Time hold a Baſin of Water in one Hand, then, upon any Non-electric Perſon touching the Water, the Snap is heard, the ungrateful Senſation perceived, and the Streaks of Fire produced as copiouſly as they before proceeded from ſolid Bodies. Nor does it make any odds in the Conſequence, though one ſhould produce artificially a much greater Degree of Cold, than ever is obſerved in the coldeſt Regions naturally.

Now in order to account for theſe Appearances, let it be obſerved that ſuch of theſe Experiments as can be tried *in vacuo* ſucceed equally well as in the open Air; therefore we muſt reject that Cauſe of the Attraction of light Bodies, and their ſucceſſive Repulſion: So that *Cabæus* the Jeſuit's Opinion falls to the Ground, who ſuppoſes that Jett, Amber, Glaſs, *&c.*

when rubbed, attract light Bodies by emitting Steams of a ſubtile Matter, which puſhes back from the electric Body the Circumambient Atmoſphere, but the Air that was juſt before repelled to ſome Diſtance, makes as it were a little Vortex, by meeting a Reſiſtance from the Particles of Air which lie at greater Diſtance beyond the Sphere of Activity of the electric Body; ſo that the Steams, when emitted, not finding a free-enough Paſſage any way, muſt recoil upon the electric Body, and in their Return bring along with them whatever light Bodies are within their reach. But this Reaſoning is entirely ſubverted by the ſole Obſervation, that the Electricity pervades the moſt ſolid Glaſs, and operates as ſtrongly, attracting and mutually repelling *in vacuo*, as in the denſeſt Atmoſphere. But this Hypotheſis does not pretend to explain the repulſive Power, which

Electrics have one to another; nor do I ſee it poſſible to account for this Property upon any ſo fallacious a Suppoſition.

Nor is the Method, by which *Gilbert*, *Digby*, and *Brown* ſuppoſe theſe Phænomena to happen, more unexceptionable; for they ſuppoſe the electric Body, when excited, emits unctuous Rays, which being cool'd by the open Air are more condens'd, and having loſt part of their former Agitation ſhrink back again to the Body, whence they came, and ſo carry with them ſuch light Bodies as are within the Sphere of their Activity, when they return to the electric Body. But without raiſing any Objections about the particular Nature of theſe Steams, which would not be an eaſy Matter to determine, this Hypotheſis, as well as *Gaſſendi*'s, is intirely over-thrown by the Experiments made in an exhauſted Receiver, where the Attraction takes place as ſtrongly as in the open Air. See Mr. *Boyle*'s *Mechanical Origin of Electr.* p. 29.

Carteſius's Opinion is ſo involved in the Obſcurity of his firſt and ſecond Matter, that I ſhall not here ſhew the Contradictions with which it abounds. But having given a brief Relation of different Philoſophers Opinions concerning this Property, and at the ſame Time ſufficiently demonſtrated their Inſufficiency, I ſhall now endeavour to give another Solution of it; and ſhall firſt premiſe one or more *Lemmata*, which I find true by Experiments.

I.

Electrical Attraction is cauſed by a material Emanation from the attracting Body, and not by any particular Sympathy, or occult Quality.

For when a Glaſs Tube is put into a State of Electricity, if it be rubbed briſkly, and brought near the Face or Hands, there is always a pleaſant warm Glow perceived. Farther, if a Perſon ſtand on a Wax Cake, and hold a Silver or China Plate in one Hand, on which Gold Leaf, Feathers, Hairs, or any light Matters are ſpread thin or ſtrew'd, and then be electrify'd by means of the Globe or Glaſs Tube, as ſoon as he is replete with the electrical Power, the light Subſtances will be raiſed from the Plate and carried into the Air by the electrical Steams which iſſue from the ſame.

II.

Some Bodies are Electrics *per ſe*, or originally Electrics, in which an attractive Power towards light Bodies either naturally exiſts, or is eaſily excited by Friction. "Others "are Non-electrics or Conductors of "Electricity, in which the above Pro-"perty is not at all or very ſlightly perceptible,"

“ ceptible,” that I may uſe the Words of the ingenious Mr. *Watſon.*

The great Mr. *Boyle* has obſerv’d that Animal Subſtances are ſometimes found to be Electrics *per ſe*, and to this Purpoſe produces the following Fact. Falſe Locks of Hair which are worn by ſome Perſons will be attracted by their Skin. “ Of this, ſays “ our Author, I had a Proof in ſuch “ Locks worn by two very fair Ladies: “ For at ſome Times I obſerv’d that “ they could not keep their Locks “ from flying to their Cheeks, and “ (though neither of them made any “ Uſe, or had any need of Painting) “ from ſticking there. When one of “ theſe Beauties firſt ſhew’d me this “ Experiment, I turn’d it into a complimental Raillery, as ſuſpecting “ there might be ſome Trick in it, “ though I after ſaw the ſame thing “ happen to the others Locks too. “ But as ſhe is no ordinary Virtuoſa,

“ ſhe very ingenuouſly remov'd my
“ Suſpicions, and, as I requeſted,
“ gave me leave to ſatisfy my ſelf further
“ by deſiring her to hold her
“ warm Hand at a convenient Diſtance
“ from one of theſe Locks taken
“ off and held in the Air. For as
“ ſoon as ſhe did this, the lower end
“ of the Lock, which was free, applied
“ itſelf preſently to her Hand: Which
“ ſeem'd the more ſtrange, becauſe ſo
“ great a Multitude of Hair would
“ not have been eaſily attracted by
“ an ordinary electrical Body, that
“ had not been conſiderably large, or
“ extraordinarily vigorous.” Lord
Bacon obſerves to this Effect, “ that
“ a thin feint Light is ſometimes
“ though but ſeldom obſerv'd to hover
“ over the Hair of certain Perſon's
“ Heads, as it were a dying Flame.
“ ſomething of this Kind happen'd
“ *Lucius Martius* in *Spain*. In the
“ ſame way ſome Perſons Wearing

"Apparel ſhines as they put them "off, whether from the Sweat of the "Body, or from the Ingredients of "the Colour which tinge them[a]".

Thus far our Author; I ſhall add to this Obſervation, that it hath been remark'd by ſeveral Gentlemen as well as by me, when Silk Stockings have been worn over woolen ones, that frequently, upon pulling them off the Legs, a crackling Noiſe and electrical Snap is heard, and after the Stockings are put off, if the Silk one be immediately laid contiguous to the Worſted, then the Attraction is ſo ſtrong between theſe Bodies as to ſuſpend the dependent Stocking.

III.

The Power of Electricity is in a continual *Niſus* to fly from the electric Body, in which it is originally implanted, or from the Non-electric which hath acquired its Virtue by Contact, with an originally Electric excited by rubbing. This appears as well by the Steams emitted from the electric Body as from the known Obſervations, that all Bodies whatever, as ſoon as they are once electrified, immediately loſe their acquired Powers unleſs they are kept in continual Agitation.

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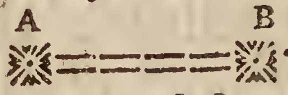
[a] *De Luce & Lumine*, Tab. 1. *præſentiæ.*

Hence it appears, that the electrical *Effluvia* endeavour continually to recede from one another.

From theſe *Lemmata* it ſeems evident to me that the true Cauſe of the repulſive Property obſerv'd between electric Bodies is this, that each Body darts out every way Files or Groups of Rays, which, meeting in the Void of the Atmoſphere in oppoſite Directions, impel one another with a determinate Force; but as they iſſue forth every way, 'tis impoſſible that two oppoſite Groups of Rays meeting together can juſtle their electrical Particles to one Side; therefore as all the Space is fill'd with ſuch ſmall Parts, they now become continuous to one another, and thereby may be conſidered to act as ſo many Solids, and by that Means re-act upon the lighteſt Electric, and in ſome Caſes even overcome its natural Gravitation, and drive it away in any Direction.

Suppoſe A and B to be electrify'd Bodies brought within the Sphere of one another's Attraction, which, for Example, ſuppoſe one Foot each; then all the Space which lies between A and B will be fill'd with electrical *Effluvia*, like Rays iſſuing from a Center, which becauſe they endeavour to recede from one another, if A be brought nearer to B, B will that inſtant, if not overcome by its natural Gravity, recede and fly off from A.  Thus it comes to paſs when a Man ſtands on a Cake of Wax,

Wax, which is Electric *per ſe*, the Electricity with which the Man is impregnated, is repelled or ſtopt by the Cake of Wax, which has naturally that electric Power, though in a very ſlight Degree, and is, by what we before demonſtrated, in a repulſive State to the electrical *Effluvia* which dart from the Man; ſo that the Man's Electricity muſt ſpend itſelf in the contiguous Atmoſphere, unleſs touch'd by ſome foreign Body.

Having thus explained the Manner of this repulſive Property of Electricity, I am of Opinion that it may not be improper to ſuggeſt to you what I take to be its proximate Cauſe: And in the firſt Place we muſt obſerve, that Electrics violently agitated emit Light, and ſhine; and this Emiſſion is perform'd by the vibrating Motion of its Parts, and as the great Sir *Iſaac Newton* obſerves, " Do not all Bodies " which abound with terreſtrial Parts,

" and eſpecially with ſulphureous ones, " emit Light as often as theſe Parts " are ſufficiently agitated, whether " that Agitation be made by Heat, or " by Friction, or Percuſſion, or Putrifaction, or by any vital Motion, " or any other Cauſe? As for inſtance, Sea Water in a raging Storm, " Quickſilver agitated *in Vacuo*, the " Back of a Cat, or Neck of a Horſe " obliquely ſtruck or rubbed in a " dark Place; Wood, Fleſh and Fiſh, " while they putrify. Vapours ariſing " from putrified Waters, uſually called *Ignes fatui*. Stacks of moiſt " Hay or Corn growing hot by Fermentation. Glow-worms and the " Eyes of ſome Animals by vital Motions; the vulgar Phoſphorus agitated by the Attrition of any Body, " or by the Acid of the Air; Amber " and ſome Diamonds, by ſtriking, " preſſing, or rubbing them. So alſo " a Globe of Glaſs, about eight or

“ ten Inches in Diameter, being put
“ into a Frame where it may be
“ ſwiftly turn'd round it's Axis, will,
“ in turning, ſhine where it rubs a-
“ gainſt the Palm of ones Hand ap-
“ ply'd to it: And if at the ſame Time
“ a Piece of white Paper, or white
“ Cloth, or the End of ones Finger
“ be held at the Diſtance of about a
“ quarter of Inch, or half an Inch
“ from that part of the Glaſs where
“ it is moſt in Motion, the electric
“ Vapour, which is excited by the Fric-
“ tion of the Glaſs againſt the Hand,
“ will by daſhing againſt the white
“ Paper, Cloth, or Finger, appear
“ lucid, like a Glow-worm, and in
“ ruſhing out of the Glaſs will ſome-
“ times puſh againſt the Finger, ſo as
“ to be felt.” Thus far Sir *Iſaac*.

That Philoſopher has beſides, by a great Variety of Experiments, determin'd that Bodies and Light act mutually on one another; that the Particles of Light are attracted by, and themſelves conſequently attract, light Bodies, and that ſome Bodies are more eaſily heated than others; particularly black Bodies conceive Heat ſooneſt, by Reaſon that the Light falling on them is not reflected outward, but enters the Bodies, and is often reflected and refracted within them until it be ſtifled and loſt. Farther that groſs Bodies and Light are convertible into one another; and may not Bodies receive much of their Activity from the Particles of Light which enter their Compoſition? The changing of Bodies into Light, and Light into Bodies, is very conformable to the Courſe of Nature, which ſeems delighted with Changes. Now, when the Rays of electrical Fire are excited by rubbing the Tube, doth it not happen that the Matter of Heat and Light, which is lock'd up in the Pores of the Body, is at that time in part ſet looſe, and by the quick

Vibrations of the internal Parts emitted with a certain Force, which is perceptible both to the Touch, Sight, and Hearing, when a proper Object oppoſes the Courſe of this ſubtile Matter by the Colliſion of the electrical Particles one againſt another, and by that Means collecting ſo many Particles together as are ſufficient to create in the Standers by the Idea of Light and Heat?

Now it may be objected, that if the electrical Matter, and the Matter of Light were the ſame, the Electricity ſhould be ſeen on all Objects, which are impregnated with it; juſt as Light ſhining on any Object is reflected from it ſo as to be eaſily ſeen in all Directions. In anſwer to this, it muſt be obſerved, that a lighted Candle, and an electric Body rubbed, have this in common to emit Light copiouſly; but the moſt luminous Space about both theſe Bodies is very near the Candle itſelf, and the electric Body; about the Candle there is a Cone of Light much brighter than the Space at a Foot Diſtance, becauſe the Vapour in the Cone is much more replete with Particles of Light, than the Space at a greater Diſtance; but though the Rays iſſuing from a Candle, fill the whole Atmoſphere with luminous Particles to the Diſtance of three Miles every Way; yet, if a Man in a dark Night, ſtand with his Back towards the Place where the Candle burns, at the Diſtance of fifty Yards, he can by no Means diſcover the Rays of Light which paſs by him in every Direction, unleſs he caſt his Eyes upon any Object that will reflect the Rays ſtrongly enough to vibrate ſufficiently on the Retina, and thereby excite the Senſation of Light in his Mind. So that Light with regard to us is only a relative Thing; for every body may have obſerved, when a Candle is brought into the bright Sun ſhine, even the moſt lucid Cone at that time projects a Shadow. Mr. *Boyle*, I think, ſome where or other tells a Story to this Effect, of ſome Man who was caſt into a Dungeon, where every thing for a conſiderable Time after appear'd with utter Darkneſs; but after a while, though no Alteration was made in the Walls of the Priſon, he gradually acquir'd his Sight to ſuch a Degree as to be able to diſtinguiſh perfectly his own Skin, and at laſt he came to read Letters. *Suetonius* tells us of the Emperor *Tiberius*, that he was gogle ey'd, and yet, which was very remarkable, could ſee at Night, and in the Dark for a ſhort Time, and this Circumſtance happen'd whenever he open'd his Eyes from ſleep, till after awhile he became dim *.

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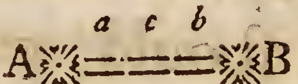
* Erat prægrandibus oculis, qui, quod mirum eſſet, noctu etiam & in tenebris viderent, ſed ad breve, & cum primum à ſomno patuiſſent, demum rurſum hebeſcebant. *Sueton Vita Tiberii* C. lxviii.

Now when a Body is ſo replete with electrical Fire as by touching it to emit Light, this is effected by a Colliſion of ſo many electrical Particles together, as by their Vibrations produce Light and Heat in theſe Bodies, where none was before obſerved; for when a Non-electric touches an electrified Non-electric, as ſuppoſe a Perſon touches an electrified Rod of Iron; at that preciſe inſtant of Contact, the Perſon's Finger becomes in a repulſive State to the Group of electric Rays, that in the next ſucceeding Point of Time ſally out of the Rod, conſequently by *Lemma* III. they are beat back upon one another, and ſo excite ſtronger Vibrations in this fine electrical Matter, which is by this Means collected in a Quantity ſufficient to impreſs our Organs of Senſe.

I ſhould, you may think, before I put an End to this Diſquiſition, mention ſome Cauſe of the Attraction of electric Bodies; but when I have conſider'd with myſelf all the plauſible Means, by which it ſometimes appear'd probable this might be done, I find none of them which will ſatisfy me thoroughly, for 'tis not ſufficient to tell you that they have ſome internal Power which attracts Bodies to them from a certain Diſtance, becauſe you muſt neceſſarily reply that this is to give Bodies a Power of acting where they are not, which is ſo repugnant to common Senſe as not to need any Anſwer. Nor is it much eaſier to ſuppoſe why the electric Rays as they iſſue from the Body, ſhould apply the light Subſtances in a ſtraight Line to one Ray after another, till by Degrees they arrive at the electric Body; for though a Group of Rays ſhould proceed from A to B, whence does it happen that B 

approaches from the more attenuated Part of the Medium *c b* to the denſer

ſer Part *c a*? Nor can I think this Explication without its Exceptions, that the Rays contiguous to the Body firſt attract, and then the next, and ſo on; that is to ſay, if a Group of Rays proceed from A to B, that the Rays which are at *b* firſt act upon B, and having brought it's Body to the Space in which they themſelves were juſt before, that then the electric Virtue at *c* comes to act, and by this Means impels the Body to *a*, which is the denſeſt Part of the Medium, and conſequently the abſolute Degree of Attraction is ſtronger than it was at a greater Diſtance.

But it may well be objected, that though the electrical Matter be extremely minute and attenuated, yet this does not by any Means alter it's eſſential Properties of Matter, ſuch as it's impenetrability and *vis inertiae*, &c. and as ſoon as ever you give it an active Power of uniting itſelf to any Matter whatever, you immediately confound the firſt eſtabliſh'd and univerſal Properties of Matter. To which I anſwer, that I have here endeavour'd to trace up the ſecondary Cauſes, till I have arrived at this Fact, which, though it happens in ten thouſand Occurrences in Life, we are ſtill at a Loſs to explain the Manner in which it is effected, and can only ſay that this differently modified ſeems to hold the laſting World in its juſt Poize and Movement.

'Tis in natural Philoſophy as in Mathematics, there are ſome Axioms which muſt be ever granted, and the Cauſe of them referr'd only to the original Cauſe and Conſtitution of Things; but whenever ſceptical Diſpoſitions will call every Thing in Queſtion, the firſt Principles of Geometry itſelf paſs not uncenſur'd, and it appears to ſome as hard to conceive *Euclid*'s Definition of a Point, *that which hath no Parts*, as others have to conceive of Attraction. But for my Part I do not ſuppoſe the Cauſe of Attraction to be mechanical, but to depend either on the immediate Action of the Deity himſelf or on ſome Agent delegated from him. I am not concerned whether this be a Medium more ſubtle than that of Electrics, or whether it be ſome immaterial Agent, whoſe Powers of Action are meerly confin'd to the narrow Sphere of Electricity and the Attraction of Coheſion. If this Agent be a material elaſtic Fluid, it is ſomething extremely rare, and from this and ſuch like Obſervations, *viz.* that the Thermometer riſes *in Vacuo* as ſoon as in open Air, that the Attraction of Electricity takes Place as well in a void as in the Atmoſphere. The greateſt Philoſophers have pleaded long ago, for the Exiſtence of ſome very ſubtile ætherial Agent, which, I think, we may ſuppoſe the Power of Electricity to be. But if we will needs find a material Cauſe of this Power itſelf, our tardy Senſes fail us in theſe more intricate Inquiries, and Facts themſelves are wanting to countenance our refin'd Speculations; ſo that we muſt here have Recourſe to ſome vital Principle, *Archæus Faber*, or *Plaſtic* Nature, ſubordinate indeed to the great Parent of all Cauſes, on whom depend either immediately or by ſecondary Means the Univerſe, and all the wonderful Variety of Scenes contained in it.

Should you after all, my Friend, be ſatisfied with this Solution and Account of the Matter I ſhall think my Labour and Time ſufficiently recompenſed, as I know you not without Judgment curious and of a diſcerning Mind; but if my Enquiries have erred from the Truth, I ſhall be happy in firſt expoſing my Miſtake to ſo candid a Friend, whoſe Love is too ſincere to wink at my Errors, without admoniſhing me of them, ſo that whatever be the Fate of theſe Papers, I am ſatisfied you will convince me that I have a Friend in you, I conclude with putting you in Mind of what Lord *Bacon* has laid down, *Terminus itaque humanæ potentiæ & ſcientiæ in dotibus quibus ipſe præditus eſt a natura ad movendum & percipiendum, tum etiam in ſtatu rerum præſentium. Ultra enim has baſes illa inſtrumenta non proficiunt.*

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[a] *De Interpretatione Naturæ, Sentent.* 2.

Dear SIR,

June 12. 1746. *Yours &c.*

F I N I S.